Research Paper | Engineering | E-ISSN No : 2454-9916 | Volume : 4 | Issue : 3 | March 2018

DESIGN AND OPTIMIZATION OF EXISTING AUTOMOTIVE SEAT RECLINER

Akhilesh Pandey [1] | Dr. P. K. Sharma [1]

[1] P.G. Student, M.Tech. Mechanical Engineering NRI Institute of Information Science and Technology, Bhopal (MP), India

ABSTRACT

The automotive industry is changing very rapidly. New components are introducing by automotive manufacturer in manner of improving passenger's comfort and safety as well as aesthetic. Safety and comfort of occupant are very important. Recliner of automotive seat is a mechanism which is give rotation to seat back forward & rearward direction from a pivot point at the base of seat back according to the passenger's seating comfort. Seat recliner is the most critical criteria in the design of seat structure in auto motive seat industry. The aim of this paper is to design and optimize the existing seat recliner subjected to loading. The scope of present work involve Finite Element Modeling of seat recliner assembly using HYPERMERSH & ANSYS. The result in the form of stress, load and displacement are extracted using FEA result.

KEYWORDS: Von Mises Stress, Yield strength, Static Seating System, Seat Recliner, Factor of safety, Static Analysis, Seat Recliner gear active & passive teeth, Low cost safety, Gear active & passive thickness, FEA.

I. INTRODUCTION:

The standard seat is designed to support thighs, the buttocks, lower and upper back, and head support. The front driver and passenger seats of most vehicles have three main parts: the seat back (squab), seat base (cushion), and the headrest.

Recliner of automotive seat is a mechanism which is give rotation to seat back forward & rearward direction from a pivot point at the base of seat back according to the passenger's seating comfort.

The current trend in automotive industry is to produce vehicles with lighter materials yet ensuring the safety for the occupant. In order to achieve this goal with minimum of expensive prototyping testing, new designs must be investigated numerically for strength and failure terms. The main objective of a good automotive seating system is not only to provide comfort but also to provide style and more importantly the safety feature. Pavan Gupta et al [1] studied that Anti-submarine Performance of an Automotive Seating System - A DOE study. But the system yet is sufficiently light weight to facilitate vehicle fuel economy and to minimize collision stresses. D. M. Severy et al were [2] developed Collision Performance LM Safety Car. Seating system design and materials must be affordable and durable to give acceptable service life. F W Babbs et al [3] studied that the packaging of car Occupants – A British Approach to seat designs. In addition to provisions for comfort and position adjustments, a seating system should have adequate structure for housing safety and convenience accessories. A. W. Siegel et al [4] were developed Bus Collision Causation and Injury Patterns. The design of seat recliner is very important because during an accident or a crash, occupants tend to be thrown back against their seat backrest due to inertial forces and if the recliner is not built to withstand such an impact, it results in failure. Toshiki Nonka et al [5] studied that the Development of Ultra-High Strength Cold-Rolled Steel Sheets for Automotive Use. Sarah Smith et al [6] were developed that the Improved seat and head restraint evaluations. Recliner failures result in Seat backrest twisting and collapse and which can lead to severe neck, back and spinal injuries. G. Nadkarni et al [7] also studied that Advanced High Strength Steel Strategies in Future Vehicle Structures. The area of interest in a recliner is usually the locking mechanism, which holds the seat back at the angle desired by the occupant. The locking mechanism needs to be designed for sufficient strength, so that the seat back does not collapse during an impact. Guillén Abásolo et al [8] developed that Magnesium: the weight saving option. C. Blawert et al [9] studied that the Automotive applications of magnesium and its alloys. The renewable materials also used in automotives, Dr.Thomas et al [10] studied that Renewable Materials for Automotive Applications. For accurate positioning of recliner and to accept the recliner mechanism the lever release should be able to with stand the applied load in the locking position. When the load is applied then the whole assembly is subjected to combined stresses. Hence the lever release strength is the basic parameter for analysis. The desired position of back rest is achieved by operating the lever. When lever is operated force is transformed to cam. Which intern unlocks the upper tooth and lower tooth.

II. DESIGN

A. Requirement:

As per Automotive Industry Standard, AIS-023, AIS-015, AI-016, automotive seat should pass Seat back strength test, Head rest performance test, energy dissipation test, seat belt anchorage test. As per ECE17, automotive seat should pass Head rest performance, Seat back strength, Head rest energy absorption, Forward & rearward impact test, Luggage retention test etc. From this tests in Head rest performance testing maximum load is coming on recliner. As per Head rest performance test requirements, 373Nm moment applied on seat back &spherical head form 165 mm in diameter, an initial force producing a moment of 373 Nm about the H point is applied at right angles to the displaced reference line at a distance of 65 mm below the top of the head restraint & increased the load till 890 N or unless the breakage of the seat whichever occurs earlier. To meet this requirement, recliners designed more than 1000Nm torque value.

B. CAD Modeling:

CAD modeling is used by many designers to create elaborate computerized models of objects before they are physically produced. CAD stands for computer aided design. Engineers, architects, and even artist utilize computers to assist in there design projects. Computers allow them to visualize their design and confront problems before they have expanded any of the resource necessary to put them into physical form. CAD modeling takes many different form depending on the type of project. Some model are simple two dimensional representations of various views of an object. Other are elaborate three dimensional cross sectional that shows every details in great depth. Some CAD model are even animated, showing all of the components of the model work together to complete its functions.

In this project, CATIA V5R20 software used for CAD modeling. CATIA enables the creation of 3D parts, from 3D sketches, sheet metal, composites, and moulded, forged or tooling parts up to the definition of the mechanical assemblies. The software provides advanced technology for mechanical surfacing & BIW. It provides tools to complete product definition, including functional tolerance as well as kinematics definition. CATIA provides a wide range of applications for tooling design, for both generic tooling and model & die.

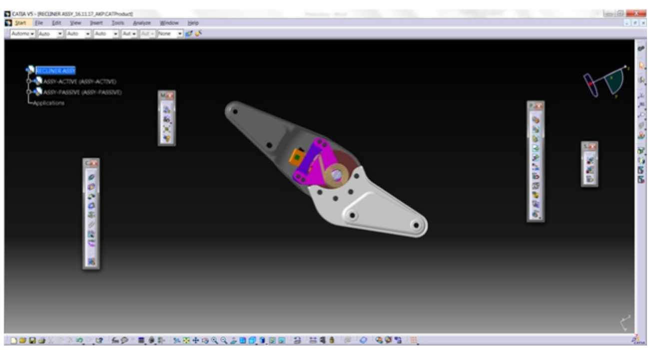

Fig. 1: Recliner assembly model

C. Recliner strength Hand calculations:

Width of tooth at Center = 0.733mm

Sector thickness = 5mm

Cross sectional area of tooth = 3.665mm2

Number of teeth's engaged = 18 nos.

Distance of teeth's from pivot = 40mm

Tensile strength of sector/pawl material = 616MPa

Shear strength =616/1.5

=410.67Mpa

Shear failure load on each teeth = 410.67 x 3.665 =1505.1N

Recliner strength = Shear failure load x Number of teeth x Distance from pivot

=1505.1 x 18 x 0.040

=1083.67Nm

III. MATERIAL SELECTION:

There are so many materials to select for Gear active & Gear passive but have to select the material which should high strength in low thickness also. Recliner have requirement to washstand with load shown above, so that material should select which have difference between Yield strength and Ultimate strength. So here there is existing material which is Fe 490

Now using the new material 16MnCr5 having material property shown in table I & II

Table I
Existing material & Thickness Used for Gear active & Gear Passive of Recliner

Material Fe 490	
% Elongation	20
Density	7850 kg/m³
Poisson's ratio	0.3
Yield strength	300 Mpa
Ultimate strength	490 Mpa
Thickness	5mm

Table II
Proposed material & Thickness Used for Gear active & Gear Passive of Recliner

Material 16MnCr5	
% Elongation	19
Density	7850 kg/m³
Poisson's ratio	0.3
Yield strength	425 Mpa
Ultimate strength	616 Mpa
Thickness	3.65mm

IV. STATIC ANALYSIS:

Seat system for passenger vehicle can rarely be designed without numerical simulation nowadays .In order to increase crash safety, at ANSYS has become an integral part of the product development process. Simulation produces reliable results which are still mandatory, and can also perform standard tasks, otherwise carried out by real test.

A static analysis calculates the effects of steady loading conditions on a structure, while ignoring inertia and damping effects, such as those caused by time-varying loads. . Static analysis is used to determine the displacements, stresses, strains, and forces in structures or components caused by loads. For Static Load FEA result first it have CAD module of seat Recliner (Gear active & Gear passive) shown in fig 1, after that it convert in meshing format so CAD module imported in Hyper mesh. In an elastic analysis of an isotropic solid these consist of the Young's modulus and Poisson's ratio of the material, then the structure is meshed into small elements, after meshing it applies the load in ANSYS for analysis the load deflection. Putting the material property and thickness information ANSYS gives the load deflection for existing & new material and thickness, so this results are used for the optimization the gear active and gear passive ANSYS software.

A. Load Condition:

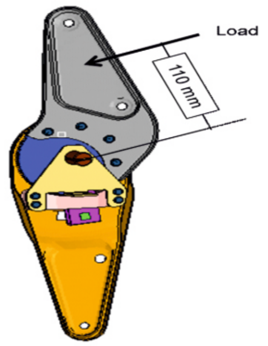

Fig. 2: Recliner mechanism

2000 Nm Torque is applied at Pivot point of the backrest on recliner.

The two mounting consider fixed at the center to represent the cushion side member mounting region. The arm representing back modeled and considered as rigid to apply the torque on the Sector plate. Force applied 110mm above from recliner pivot to find out torque. Handle spring force (10N) considered for cam locking and clock spring force (30N) considered for back returning.

B. FEA Analysis:

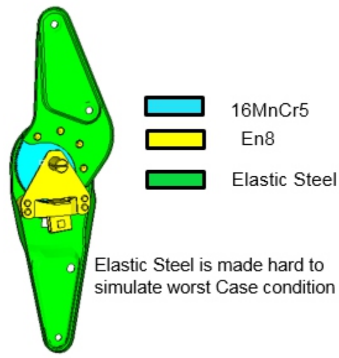

Fig. 2: Recliner mechanism

Table III
Material physical properties

SR NO	MATRIAL NAME	DENSITY (T/mm^3)	E (N/mm^2)	YIELD STRESS (N/mm^2)	ULTMATE STRESS (N/mm^2)	STRAIN	µ
1	16Mn_Cr5	7.85E-9	250000	950	1200	1.25%	0.3
2	En8	7.85E-9	250000	465	750	12%	0.3
3	Elastic Steel	7.85e-9	210000	-	-	-	0.3

Table IV
Material specification

Sr no	Name	Snap	Mtl.	Thk (mm)
1	Gear Active		16Mn Cr5	3.65
2	Gear Passive		16Mn Cr5	3.65
3	Center Shaft		En8	Ø16
4	Mtg Rivits		En8	Ø9
5	Spiral Spring		IS445 4DM	2

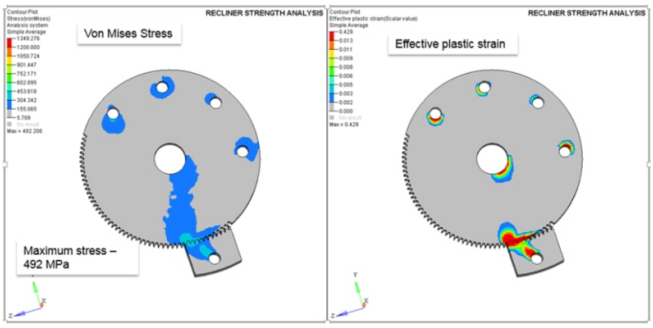

Fig. 4: sterss and strain calculation

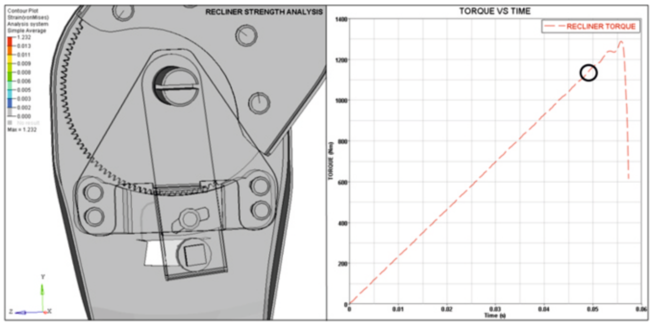

Fig. 5: Force Vs Displacement

Fig 4 shows Von Mises Stress contour in Gear active and passive. There is possibility of breakage on teeth of passive gear and active gear at near 900 Nm. overall observed torque capacity is 1100 Nm

Fig 5 shows 800 Nm torque teeth breaking starts. After 930 Nm torque Gear active breaks. As per the considered material recliner can sustain 1100 Nm torque before overall teeth failure.

V. EXPERIMENTAL SETUP:

Fig. 6: actual seat recliner and set up

Fig 6 showing actual seat recliner and the actual setup for testing of seat back strength test. This setup has given actual value of the recliner SBS test. Recliner has manufactured separate part of back and cushion arm, assemble it and create the actual working recliner. This recliner put on the setup which has mounting and acted the desired load on it shown in Fig 6.

VI. RESULT:

Sr No	Method	Condition	Load	Weight
1	Hand Calculation	Complete Seat Load	1083.67Nm	
2	FEA	Individual Recliner	1100Nm	1.121Kg
3	Load Test	Individual Recliner	900N	1.165Kg

The result shows that there is some changes in material and thickness which is affected directly on the seat recliner weight, some weight has loss here by recliner assembly with bearing all load without failure of track.

VII. CONCLUSIONS:

As per all result showing that where the torque coming on complete seat which is 1083.67NM from the hand calculation. Similarly from FEA analysis for 16MnCr5 material with 3.65mm thickness. By experimentally the load apply on the recliner 900N the recliner is peel off from the load 1000Nm which is acceptable from the recliner.

So this study is observed that by using 16Mncr5 material with 3.65 thickness, the weight reduce with acceptable test load.

VIII. ACKNOWLEDGMENT:

Thanks to Dr. PK Sharma for his valuable guidance. Also thanks for Metasys Testing and Calibration Laboratories LLP for actual testing of recliner give the accurate results.

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